ELECTRICAL-FIELD ASSISTED FLASH JOINING OF CERAMIC OXIDE-CERAMIC OXIDE AND CERAMIC OXIDE-METAL

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Joining of ceramic oxides to themselves or to metal plays crucial role in extending their applications. A variety of joining techniques have been developed in the last decades, which are generally divided into liquid-state bonding (LSB) and solid-state bonding (SSB). However, these methods are restricted due to their high joining temperature and long dwelling time, and more importantly the low use temperature. Inspired by the recently developed flash sintering technique, where the green body is fully densified in seconds at temperatures far below the traditional sintering temperatures, we herein demonstrated a novel electrical field-induced flash-bonding technique for the joining of ceramic oxides-ceramic oxides and ceramic oxides-metal.

For the ceramic oxides-ceramic oxides bonding, zirconia ceramic (ZrO_2) was selected for its outstanding mechanical property and extensive application. Zirconia ceramic was flash joined at temperatures as low as 600 ^oC in ca.1s by applying an electrical field above threshold. The bend strength of the joint was 78% of the parent material, and the strength was further increased to 95% of the parent material when the joining temperature was elevated to 900 ^oC. More importantly, the joint strength formed in optimized joining time could be equivalent to the parent material. Ultrafast superplastic deformation of the faying surfaces and the subsequent flash mass transport under the applied electrical field were proposed as the underlying mechanism.

For the ceramic oxides-alloys system, the Ni based and Ti based alloy were chosen for their ultrahigh strength and widely application in the areas of aerospace. ZrO_2 was strongly bonded to the alloys within 30 seconds assisted by the critical electrical field at temperatures from 700 ^oC to 800 ^oC. The shear strength of joined samples were greatly affected by the applied current density, holding time and the bonding temperature, as well as the direction of the field, and reached 133 MPa and 67 MPa for the ZrO_2-Ni alloy and ZrO_2-Ti alloy system. Moreover, the resultant joint can be readily de-bonded by reversing the field. The electrical field-induced internal reaction between the ceramic and metal was proposed as the mechanism for the reversible and ultrafast bonding.